METHOD OF SEMIAUTOMATIC SEGMENTATION FOR THE ESTIMATION OF THREE-DIMENSIONAL VOLUMES

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BACKGROUND OF THE INVENTION

The present invention concerns the estimation of the volume of a three-dimensional object, notably, in medical imagery.

In some medical imagery applications, there is a need to know precisely the volume of three-dimensional objects like, for example, an organ or an organ part of the human body.

It is possible through such methods to approximate the volume of an object by knowing the contour of that object along different sections, the outline between the sections then being modeled by a continuous slope. The three-dimensional object is thus modeled by a plurality of thin truncated cone-shaped volumes. However, this method requires an operator to plot the contour of the object, which demands slow and painstaking work.

BRIEF SUMMARY OF THE INVENTION

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The present invention seeks to solve the problems of the above procedure by ~~proposing~~ a method that is simple, easy to use and enables the desired precision to be obtained in a short time.

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The method is intended for estimation of the volume of a three-dimensional object in medical imagery, a contour of the object being known by means of a plurality of ~~films~~ images taken in section.

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The method comprises the following steps:

- define a given number of base points constituting a first three-dimensional shape defined by facets whose vertices are the base points;

- each facet of the first shape being defined by three segments and each segment being common to two adjacent facets, the segments are divided by creating second rank points adapted to the contour of the object, so as to constitute a second three-dimensional shape closer to the contour of the object than the first shape, the creation of a second rank point resulting in the creation of two new facets and three new segments;

- each segment is iteratively divided into subsegments adjusted by defining third rank points adapted to the contour of the object, so as to constitute a third three-dimensional shape closer to the contour of the object than the second shape, the creation of a third rank point resulting in the creation of two additional ~~new~~ facets and three additional ~~new~~ segments; and

- then, the volume of the third three-dimensional shape is calculated.

Thus, only points have to be defined and not a contour, which facilitates the work.

In one embodiment of the invention, the images were ~~films are~~ taken along parallel sections.

In another embodiment of the invention, a plurality of images ~~films~~ is treated to supply a description of the three-dimensional volume.

Each segment is advantageously divided into two.

In one embodiment of the invention, the position of each second rank point is proposed as a function of the position of the first two adjacent points or vertices. Each second rank point can thus be proposed as a function of the orientation of the perpendiculars to the first two adjacent points or vertices.

In one embodiment of the invention, the segments are divided into subsegments until the change of volume resulting from a given division is

negligible. One can thus choose a change of threshold volume below which the iterative division into subsegments is stopped. ~~Said~~ The threshold of change of volume corresponds to the desired precision of the method.

In one embodiment of the invention, six first base points, available on top and bottom, in front and back and on each side edge of the object, are defined.

A calculation of distribution of the density of the object in space can be made subsequent to calculation of the estimated volume of the object.

Any point of the three-dimensional shapes can be modified manually, for example, to adapt it to an irregularity in the relief of the object, such as a hollow or a boss. A different weighting is given to the points in order to approximate the real contour of the object as closely as possible. A modification of a first base point will result in a corresponding modification of the set of neighboring points. On the other hand, a modification of a third point of the third shape will not result in any modification of the first and second adjacent points and may slightly modify the position of the third adjacent points. Improvements of the different shapes leading to bringing them closer to the real contour of the three-dimensional object can thus be carried out very flexibly.

Similarly, to preserve a great flexibility of use, any point, including third rank, can be defined manually.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood and other advantages will emerge from the detailed description of an embodiment taken nonlimitatively and illustrated by the attached drawings, wherein:

Figure 1 is a view in perspective of a final shape according to an embodiment of the invention;

to better understand

Figures 2 and 3 are two-dimensional schematic views of the method ~~according to~~ of the invention; and

Figures 4 and 5 are three-dimensional schematic views of the method according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

As can be seen in Figure ~~4~~ 1, a final shape approximating a three-dimensional object is formed by a plurality of facets defined by three segments, for example, segments 1 to 3, defining a flat triangular surface 4. The volume of the three-dimensional object, not represented, is thus approximated by means of triangular surfaces, the coordinates of whose vertex points are known. The volume of the shape can thus be calculated.

An operator begins by defining six points of the object, an upper point 11, a lower point 12, a left side point 13, a right side point 14, a front point 15 and a back point not visible in Figure 1. This first shape thus roughly defines the three-dimensional object, and these six points must be positioned precisely, for on their definition depends that of the future adjacent points. In order to obtain a satisfactory definition, it may be necessary to check their positioning on different sections of the object.

After having defined the six first points, an oblique view is added to the existing view, making it possible by orientation and centering to define additional points.

The additional points can then be defined at the intersection of the perpendicular to one of the segments of the base volume, the perpendicular being calculated from the facets and points forming that segment, and from the edge of the three-dimensional object studied. A number of second points constituting a second shape is defined manually or automatically. When the

change of volume resulting from the definition of second points becomes less than a threshold, the definition of points can then be continued automatically, proceeding with the segmentation of existing facets until a sufficient correspondence with the three-dimensional object studied is obtained, thus constituting a third shape. The definition of points can, nevertheless, be pursued manually.

When the final volume is defined, points whose definition does not satisfactorily correspond to an irregularity in the three-dimensional object studied, notably, a hollow or a protuberance, can be modified. The point is then displaced according to the perpendicular to the facet to which the point belongs, the perpendicular being calculated from the facets.

The points adjacent to the points modified will also be modified in order to maintain the regularity of the volume defined, by taking into account the belonging of ~~said~~ the point to the first, second or third shape. The displacement of a point of the first shape results in a corresponding displacement of all the adjacent points. The displacement of a point of the third shape does not result in displacement of adjacent points of the first and second shapes.

Figures 2 and 3 show schematically, in two dimensions, as an understanding of the process of definition of the points. From a contour 20, first base points 21 to 23 are defined and make it possible roughly to define ~~said~~ the contour 20. The straight-line segments 24 to 26 joining the first base points 21 to 23 are then defined. The perpendiculars 27 to 29 to those segments 24 to 26 are then calculated. Second points 30 to 32 more precisely approximating the contour 20 can then be defined by being displaced along perpendiculars 27 to 29. The segments 33 to 38 joining points 21 to 23 and 30 to 32 are then defined, which makes it possible to reproduce the previous stages manually, semiautomatically or automatically until the desired precision is obtained.

Figures 4 and 5 show schematically, in three dimensions, the process of definition of the points. Two facets 40 and 41 belonging to a contour are represented. Facet 40 is limited by base points 42, 43 and 44. Facet 41 is limited by base points 43, 44 and 45. Base points 43 and 44 are therefore common to facets 46', 41' ~~40 and 41~~ and define a segment 46. A second-order point 52 ~~47, is next~~ defined in Figure 5, which results in the creation of additional facets 48 and 49 and additional segments 50 to 53 ~~52~~.

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In the invention, a method ~~of estimation~~ of the volume of a three-dimensional object suited to X-ray imagery is made available, which is easy to use, for there is only a small ~~number of points to be~~ defined on the edge of the three-dimensional object, as is easy to check, which guarantees a good approximation of the contour in rapid time, since the automatic definition phase can be carried out in a few seconds and is readily reproducible, insofar as it is based on the definition of a small number of points on the contour of the object.

Various modifications in structure and/or steps and/or function may be made by one skilled in the art to the disclosed embodiments without departing from the scope and extent of the invention.